Unhealthy Citrus Leaf Detection Using Machine Learning Techniques

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Abstract: The project presents a groundbreaking solution to the challenges faced by citrus agriculture in identifying and mitigating diseased plants. This application development initiative aims to harness the power of modern machine learning methodologies to accurately and efficiently detect unhealthy citrus leaves, thereby enabling timely intervention and safeguarding agricultural yield.

Keywords: Unhealthy citrus leaves detection, CNN, OpenCV2, TensorFlow, Keras

I. INTRODUCTION

Rapid advances in computer vision and machine learning have paved the way for innovative solutions in various domains. One such application is the detection and classification of diseases in agricultural crops, which play a key role in ensuring food security and sustainable farming practices. In this context, our project focuses on developing a citrus disease detection system using deep learning techniques.

Our work aims to leverage Convolutional Neural Networks (CNN) to automatically identify and classify common citrus diseases from digital images. The dataset used for training and evaluation includes images of healthy citrus plants as well as images affected by diseases such as citrus canker, greening, etc. Using advanced image classification techniques, we aim to contribute to the early diagnosis of diseases in citrus crops, enabling timely intervention and mitigation strategies for farmers.

In this report, we present the architecture and implementation details of our citrus disease detection model, evaluate its performance on a test dataset, and discuss potential improvements and future directions for research in this domain.

II. LITERATURE SURVEY

Current research on citrus plant disease detection mostly relies on traditional methods that face limitations in terms of accuracy and speed. Although image processing techniques are used in some projects, stability problems may occur in different environments. Also, the problem is the reliance on predefined properties and limiting changes to different data.

In contrast, our project takes a unique approach by using the power of machine learning. Using deep learning techniques, specifically convolutional neural networks (CNN), we aim to improve the accuracy and adaptability of detecting citrus leaf defects. The use of CNN allows automatic feature extraction, allowing our model to learn complex patterns, leading to more efficient and effective solutions. This new combination of advanced techniques sets our project apart and promises to be a major breakthrough in plant disease research.

III. PROBLEM STATEMENT

The "Citrus Leaf Disease Using Machine Learning" project aims to improve the identification of diseases in citrus plants using advanced machine learning. The real problem lies in the inefficiency of existing methods, which often rely on poor evaluations and do not require identifying signs of the disease in different settings. Our project addresses this problem by integrating advanced technology, specifically neural networks (CNN), into an application that can detect when citrus leaves are not good. Using CNN enables automatic inference by enabling the model to identify complex patterns indicative of disease. This technology not only improves accuracy but also provides farmers with solutions and flexibility. The problem statement of the project mainly talks about the inadequacy of existing methods in reducing diseases in citrus cultivation. Our program provides solutions and technologies that use machine learning techniques to provide farmers with tools that can improve early detection of citrus leaves that are not good for protecting agriculture.

IV. METHODOLOGY

The project employs a sophisticated methodology centered around Convolutional Neural Networks (CNNs), a class of deep learning algorithms renowned for their excellence in image recognition tasks.
The process unfolds in distinct modules:

1. **Data Preprocessing Module:**
Raw image data undergoes preprocessing to enhance quality and consistency.
Augmentation techniques are applied to diversify the dataset, improving model generalization.

2. **Convolutional Neural Network Module:**
Convolutional layers extract hierarchical features from input images.
Activation functions introduce non-linearity, capturing complex patterns.
Pooling layers reduce spatial dimensions, preserving essential information.

3. **Flattening and Fully Connected Module:**
Extracted features are flattened into a one-dimensional vector.
Fully connected layers facilitate intricate pattern recognition and classification.

4. **Output Module:**
The final layer produces a probability distribution over potential classes.
The model predicts the likelihood of citrus leaves being unhealthy based on learned features.
By orchestrating these modules, our methodology optimally combines feature extraction, pattern recognition, and classification.

V. ARCHITECTURE

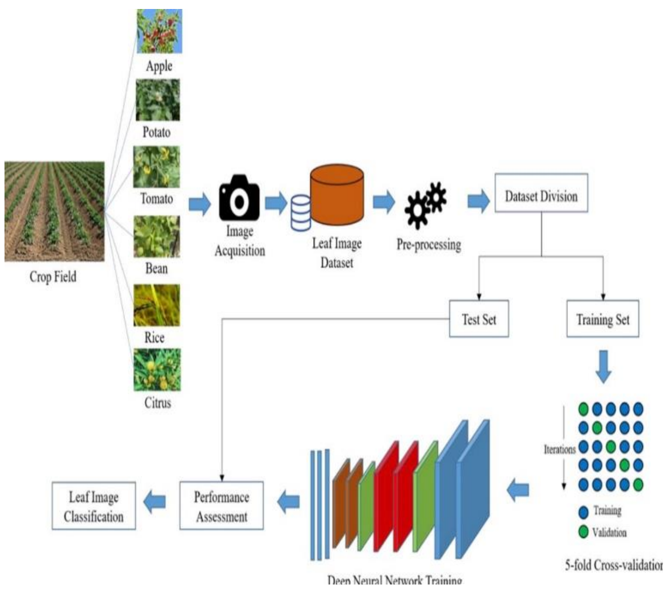

Figure 1: Architecture

VI. EXPERIMENTAL RESULTS

```
Found 607 images belonging to 5 classes.
Found 607 images belonging to 5 classes.
Epoch 1/10
19/19 [==============================] - 179s 9s/step - loss: 1.8113 - accuracy: 0.38
Epoch 2/10
19/19 [==============================] - 44s 2s/step - loss: 0.9725 - accuracy: 0.573
Epoch 3/10
19/19 [==============================] - 44s 2s/step - loss: 0.7059 - accuracy: 0.685
Epoch 4/10
19/19 [==============================] - 44s 2s/step - loss: 0.5288 - accuracy: 0.804
Epoch 5/10
19/19 [==============================] - 44s 2s/step - loss: 0.3571 - accuracy: 0.879
Epoch 6/10
19/19 [==============================] - 44s 2s/step - loss: 0.1926 - accuracy: 0.955
Epoch 7/10
19/19 [==============================] - 44s 2s/step - loss: 0.2060 - accuracy: 0.930
Epoch 8/10
19/19 [==============================] - 44s 2s/step - loss: 0.0825 - accuracy: 0.983
Epoch 9/10
19/19 [==============================] - 45s 2s/step - loss: 0.0749 - accuracy: 0.985
Epoch 10/10
19/19 [==============================] - 45s 2s/step - loss: 0.0439 - accuracy: 0.995
19/19 [==============================] - 14s 689ms/step - loss: 0.0276 - accuracy: 1.
Test accuracy: 1.0
```

Figure 3: Model Training

```
loss: 1.0921 - accuracy: 0.5140

loss: 0.7079 - accuracy: 0.7166

loss: 0.4268 - accuracy: 0.8320

loss: 0.2933 - accuracy: 0.8913

loss: 0.2076 - accuracy: 0.9341

loss: 0.1018 - accuracy: 0.9736

loss: 0.0537 - accuracy: 0.9901

loss: 0.3640 - accuracy: 0.8699

loss: 0.2429 - accuracy: 0.9374
 - loss: 0.1176 - accuracy: 0.9868
```

Figure 4: Test Loss and Accuracy

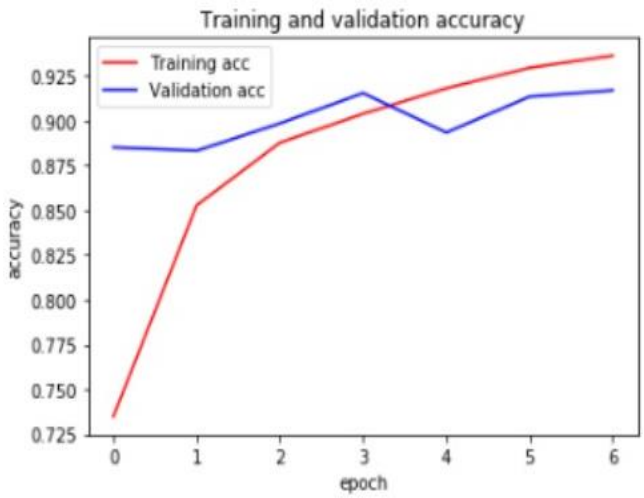

Figure 5: Accuracy Graph

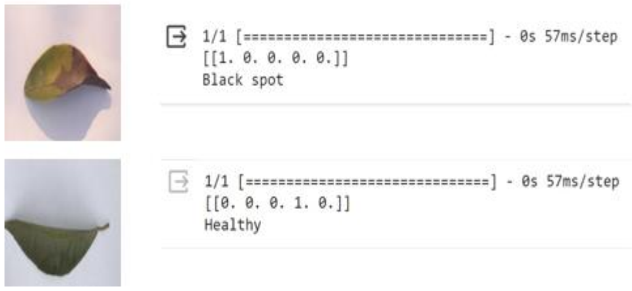

Figure 6: Model Input and Output

VII. CONCLUSION

In conclusion, the "Detection of Unhealthy Citrus Leaves using Machine Learning Techniques" project represents a pioneering endeavour to address the critical challenges faced by citrus agriculture. By incorporating advanced machine learning methodologies, particularly Convolutional Neural Networks (CNNs), our project introduces a precise and efficient solution for the early detection of diseased citrus leaves. The application developed as part of this initiative offers a practical tool for farmers, enabling timely intervention and safeguarding agricultural yield. This project not only advances the technological landscape in plant disease detection but also holds the potential to significantly impact the agricultural sector, contributing to the sustainability of citrus cultivation. The successful integration of cutting-edge technology positions our solution at the forefront of advancements in precision agriculture, underscoring its relevance and potential for positive, real-world impact on citrus crop health and overall agricultural productivity.

VIII. FUTURE WORKS

Despite the progress made in our citrus disease detection model, there are several avenues for future research and improvement.

Fine tuning and transfer learning: Explore the performance of pre-trained models such as ResNet or MobileNet for citrus disease detection. Fine-tuning these models on our dataset can yield improvements in accuracy.

Ensemble Methods: Explore the integration of ensemble methods, combining predictions from multiple models to increase the robustness and generalizability of a citrus disease detection system.

Hyperparameter Tuning: Do a thorough exploration of hyperparameter tuning to optimize model performance. This includes experimenting with learning rate, batch size, and other parameters.

Explainability and Interpretability: Incorporate methods to explain and interpret model predictions to make the system more transparent and credible to end users, especially farmers and agricultural professionals.

Real-time deployment: Explore the feasibility of deploying the citrus disease detection model in real-time applications such as on-site monitoring using edge devices or mobile applications.

Continuous expansion of the dataset: Continuously update and expand the dataset with new images, including different varieties of citrus plants and other cases of disease manifestations, to improve the adaptability of the model to different scenarios.

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